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THE JAPANESE SPACE PROGRAM (LE PROGRAMME SPATIAL JAPONAIS),(U)
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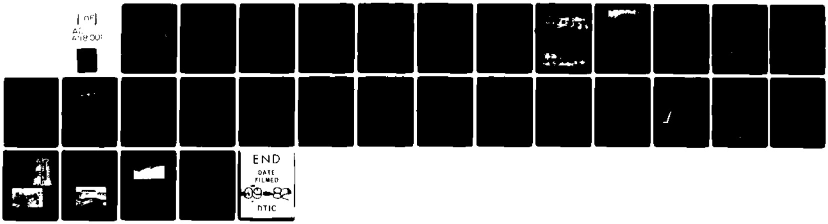

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Le programme spatial japonais

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THE JAPANESE SPACE PROGRAM* **/54

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*Talk at the AAAF and its Satellites and Space Vehicle Committee delivered on Thursday, 9 April 1981, in the spaces of the Agence Spatiale Européenne [European Space Agency] (ASE) at Paris. Mr. Contant is an engineer with the Sociéte Aérospatiale, Paris.

The Japanese space program really started in 1970 with the launching of the first satellite OSUMI by the solid rocket Lambda 4S. Following a series of failures of its domestic launcher, Japan has engaged a close cooperation in space with the United States. From that time, Japanese companies have looked for an American partner. NASDA prefers also to develop launcher projects under US license to challenge other space powers and to fill the gap on space markets.

Japan is now the third by the number of satellites in orbit (20) and by the amount of money spent in space. Japanese industry strongly intends to reinforce its position:

--14 satellites will be launched in the next 5 years and 80 in the next 15 years;

--the disposal of the H launcher (H1A by 1988 and H1B by 1990) could bring Japan to operate a reusable manned space transportation system;

--the building of a second launch pad is planned in the next 5 years at the Tanegashima space center (already larger than Kourou);

--and Japan is also determined to be a user of the US Space Shuttle.

Japanese Political and Industrial Organization

Three agencies, under the direction of the Cabinet, share the initiative in the space activity in Japan:

1. The Space Activities Commission (SAC), charged with the development policy and programs. It is under the prime minister.

2. The National Space Development Agency (NASDA), charged with the practical applications (created in 1969). It is under the guidance of the Science and Technology Agency, itself directly under the prime minister, the minister of posts and telecommunications, and the ministry of transport.

3. The Institute of Space and Aeronautical Science of the University of Tokyo (ISAS); created in 1964, it is charged with the scientific research and is under the Ministry of Education. /55

**Numbers in right hand margin indicate pagination in the original text.

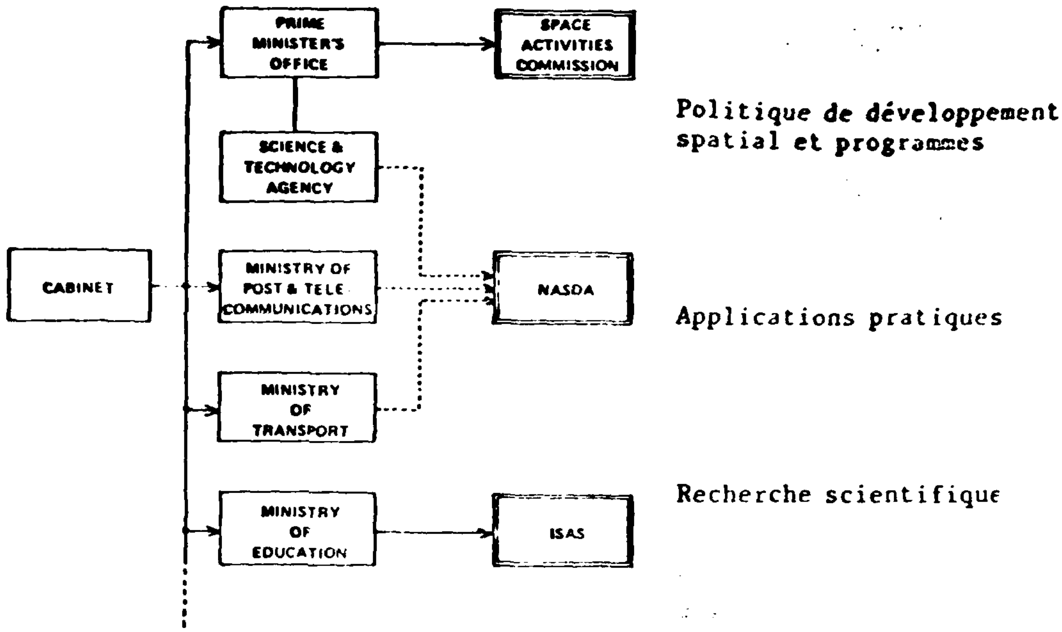

Fig. 1. Japanese organization in the space sector

a. Space development and programs policy
b. Practical applications c. Scientific research

Strategy

The Japanese strategy breaks down into three periods of 15 years each:

--the advanced technologies phase (before 1975);
--the technologies application and completion phase (1975-1990);
--global-scale activities phase (after 1990) with large reusable space transport systems.

Japan is putting into effect development series which are producing specific development programs.

The development series are of three types:

--development studies (systems design);
--development (up to launch);
--operations for satellites in service.

The development programs are reviewed annually by the Space Activities Commission (SAC) in light of the technical advances, market needs, and the financial situation. The preliminary or basic studies are examined by the Commission at the same time as the development programs.

The development of the Japanese space program remains constantly in agreement with the major strategy lines defined by the prime minister with the concurrence of the Space Activities Commission.

Basic Principle of the Japanese Space Policy

1. Market needs and national resources

The civilian space requirement must fully and effectively meet the varied national needs, and must work at developing a system which will be able to be used broadly by the public.

Thus, Japan must select long-term developments which at one and the same time permit solving the necessary, urgent, and economic needs while taking into consideration the national resources.

2. Autonomy in space development

Japan is aware of her dependence on technologically advanced nations, particularly the United States. Consequently, she has set a goal of developing her own technologies to prepare for future space developments but without imposing the obligation to produce everything by herself. From all the evidence, Japan has made up her mind to proceed quickly in order to assume a choice position in the domain of space. Therefore, her strategy is based on:

--industrial support from the United States;
--development in Japan of the key technologies (e.g., cryogenics) without slowing the rate for all that. /56

3. International cooperation

Japan started by developing various products (MU, N, H launch vehicles, various satellites) for her own needs and has demonstrated her technological capabilities. She considers as an "obligatory" objective (and this was quite evident during the last IAF Congress) to participate in projects in cooperation with other countries (manned flight, low-deceleration recovery), she is also planning to use the space shuttle and other means in order to maintain her level at the international standard.

Priority Objectives in Space*

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*The financial resources report is very enlightening on the priorities:

--20% of the budget to ISAS;
--80% of the budget to NASDA.

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1. Japanese scientific research, which has obtained recognized results at the highest level, intends to continue promoting the development of science and its applications in Japan.

2. The stress will be placed on satellites with applications in consideration of foreseeable advances, particularly in the field of communications, TV weather and ionospheric observation. At the same time, the Japanese will exploit a number of applications in the fields of navigation, geodesy, observations of the oceans, resource and environmental control, processing of materials and the life sciences.

The object of each program will be:

--to reduce the work on the ground;
--to increase the sophistication of the missions;
--to simplify operations;
--to reduce costs.

3. To satisfy the market demand by 1990 at the latest in the following fields:

--observation of the oceans, communication with ships, position finding, etc..., this because Japan is a country with a powerful maritime industry;

--study of earth resources, monitoring of natural calamities (earthquakes, typhoons...) and of pollution--this dictated by her own national needs;

--processing of materials in space, because Japan has a lead and will be technologically independent;

--techniques common to satellites, such as space platforms (fabrication, transport), because Japan wishes to be present during long-term platform flights in space.

The Large-Scale Development Series for the Next 15 Years

1. Telecommunications

--series of satellites for communication with moving bodies (series with respect to problem of inter-satellite communication;

--series of navigation satellites.

2. Observations

--series of scientific satellites for astronomical observation;

--"engineering test satellites" series for the development of engineering techniques;

--series of satellites for observation of the earth and of the magnetosphere-ionosphere;

--series of weather satellites (three-axis stabilization, study of vertical structure of the earth);

--series of probes for exploration of the moon and the planets.

Future Missions

Japan is studying the feasibility of space factories, space laboratories, space power stations, Jupiter-type probes, manned vehicles and manned orbital transfer vehicles. For the last missions, the stress in Japan is placed on international cooperation.

Japanese Launch Vehicles

The Japanese launch vehicle program began in 1955 with the development of a series of LAMBDA probe rockets by the Institute of Industrial Science (IIS), which then became the Institute of Space and Aeronautical Sciences (ISAS). It is this fifteen-year experience which permitted the University of Tokyo to accomplish the MU launch and to orbit 10 satellites (2 failures) to date.

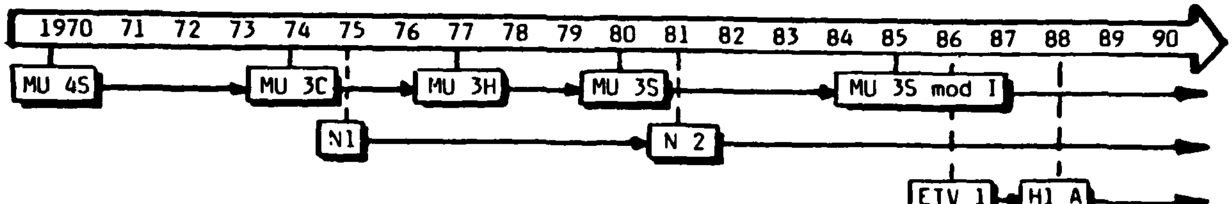
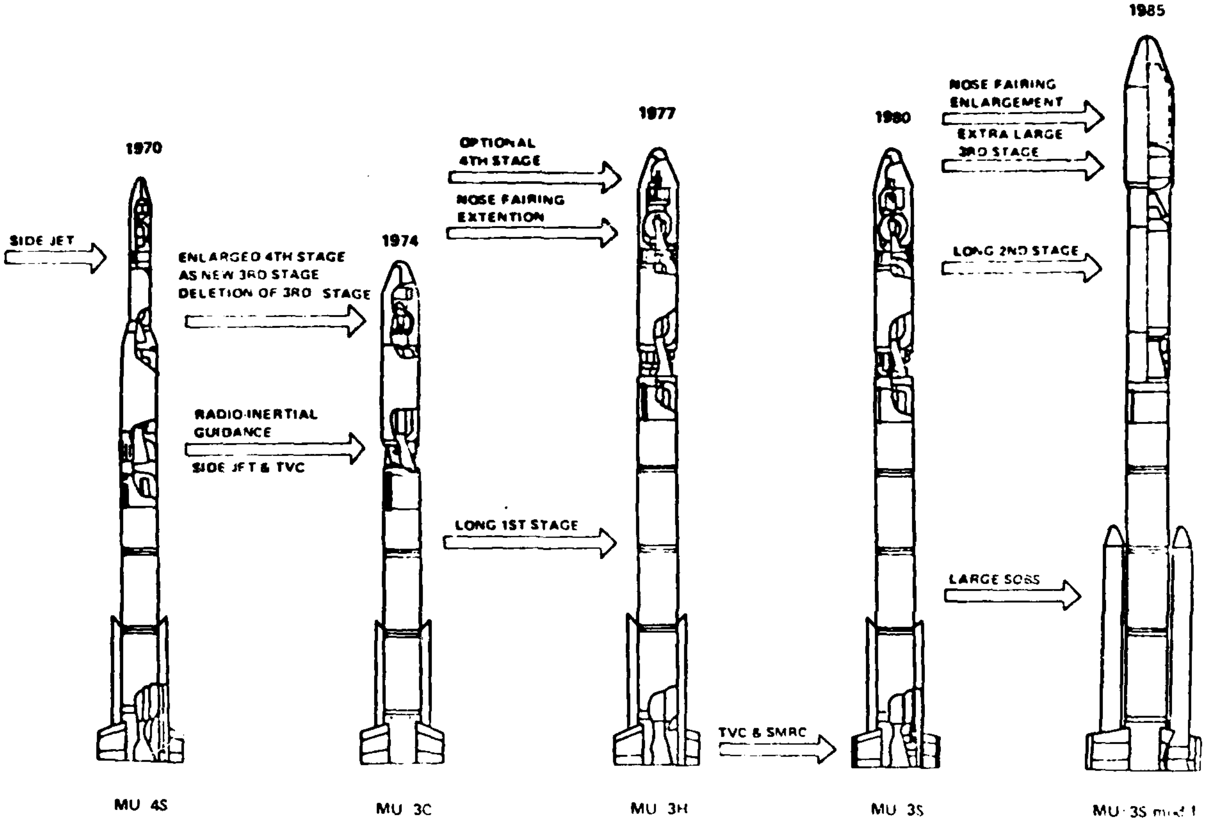


Fig. 2. – Les lanceurs japonais.

Fig. 2. The Japanese Launch vehicles



3. Evolution of the MU launch vehicle from 1970 to 1985 /57

The MU Family of Launch Vehicles

The MU launch vehicle is developed from the LAMBDA 4S, which on 11 February 1970 orbited a 24-kg vehicle named OSUMI. Consequently, the fundamental engineering of the MU launch vehicle has remained fundamentally that of the probe rocket, even if the weight and performances have increased considerably.

The objective of this launch vehicle family is to put on station all the Japanese scientific satellites; the applied satellites are reserved for NASDA with the N and H launch vehicles.

MU 3S, the most recent version of the MU launch vehicle, in February orbited the satellite TANSEI 4 (launch vehicle No. 1) and, on 21 February 1981, the astronomy satellite ASTRO A (195 kg) was placed in a circular orbit at an altitude of 500 km and an angle of inclination of 30°.

Fig. 3 shows the evolution of the MU launch vehicle.

MU 4S was developed in 1970. It was a four-stage solid-fuel launch vehicle with a very simplified guidance, except for the fourt stage (jet deflection).

MU 3C, developed in 1974, was a three-stage solid-fuel launch vehicle. The first two stages were those of the MU 4S, the third stage of the MU 3C was, in fact, the enlarged fourth stage of the preceding rocket. The second stage of the MU 3C incorporated radio-inertial guidance, a gyro platform controlled the injection of a liquid for deflection of the blast, and the side jets for control of roll.

MU 3H had an extended first stage and an enlarged nose fairing permitting a fourth stage to be added.

MU 3S has guidance druing the propulsion phase of the first stage (thrust, roll). For the other stages, they are identical to the MU 3H.

MU 3S Mod I and the MU 3U which is supposed to fly in 1985 is an MU 3S modified by the addition of more powerful boosters and a lengthening of the second and third MU 3S stages.

MU 3S Mod II is said to be the final version of the MU family. This launch vehicle is under study, and there are not yet any precise data on it. Like the N family, it is said to have a larger number of boosters and an LOS-LH_2 second stage.

Fig. 4 presents the performances of the MU launch vehicles.

Technical Characteristics of the MU 3S

The total length of the MU 3S is 23.8 m and its diameter, 1.41 m. The total weight is 49.5 t for a payload of 300 kg in low orbit.

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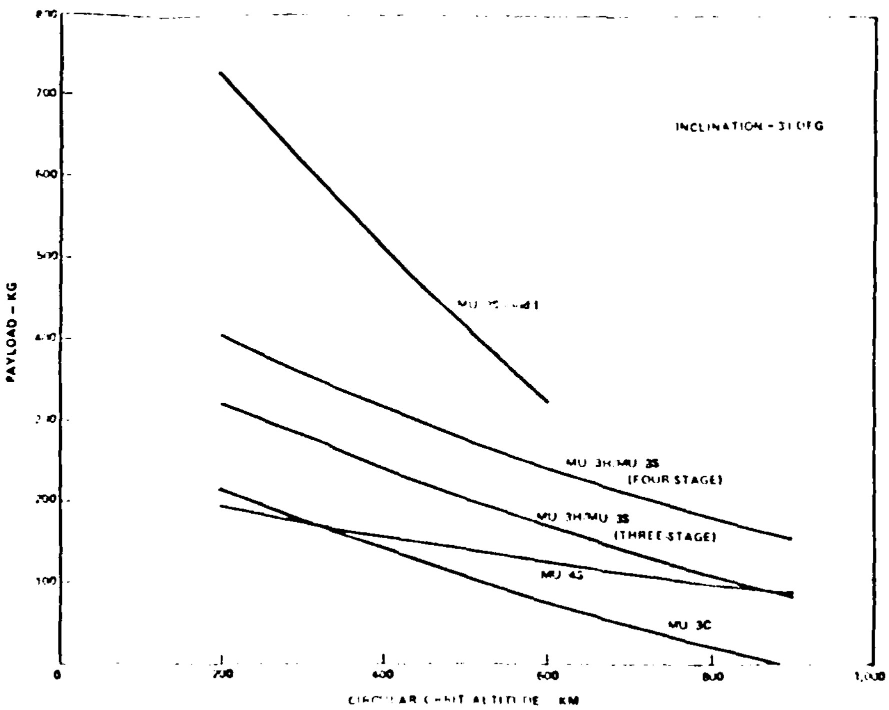
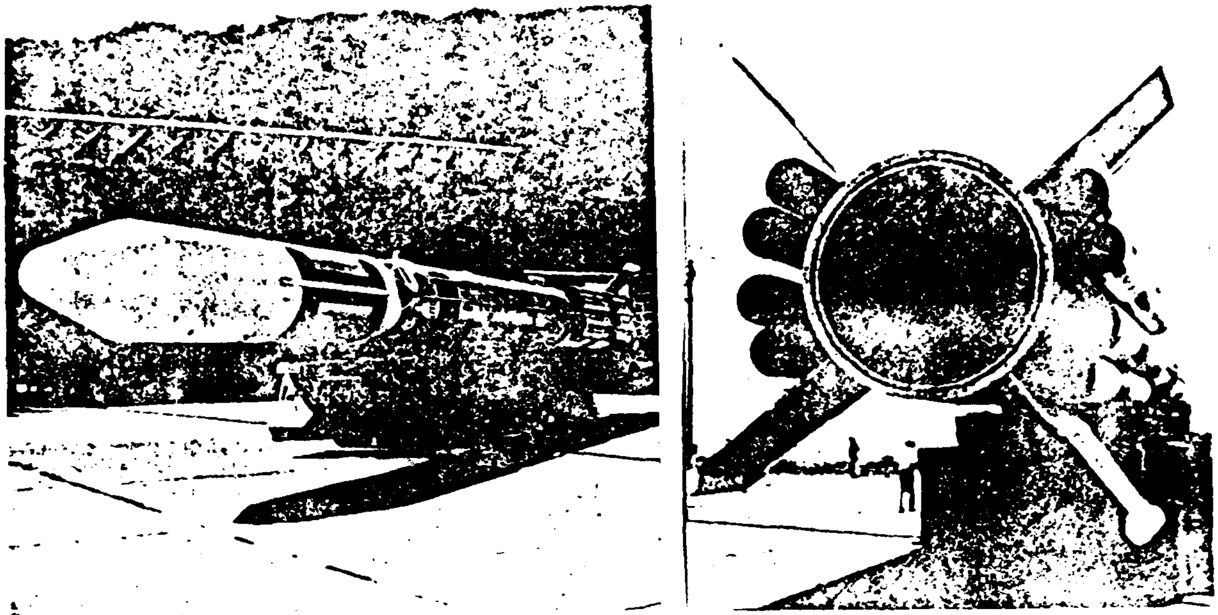


Fig. 4. Performances of the MU launch vehicles (inclination: 31°)

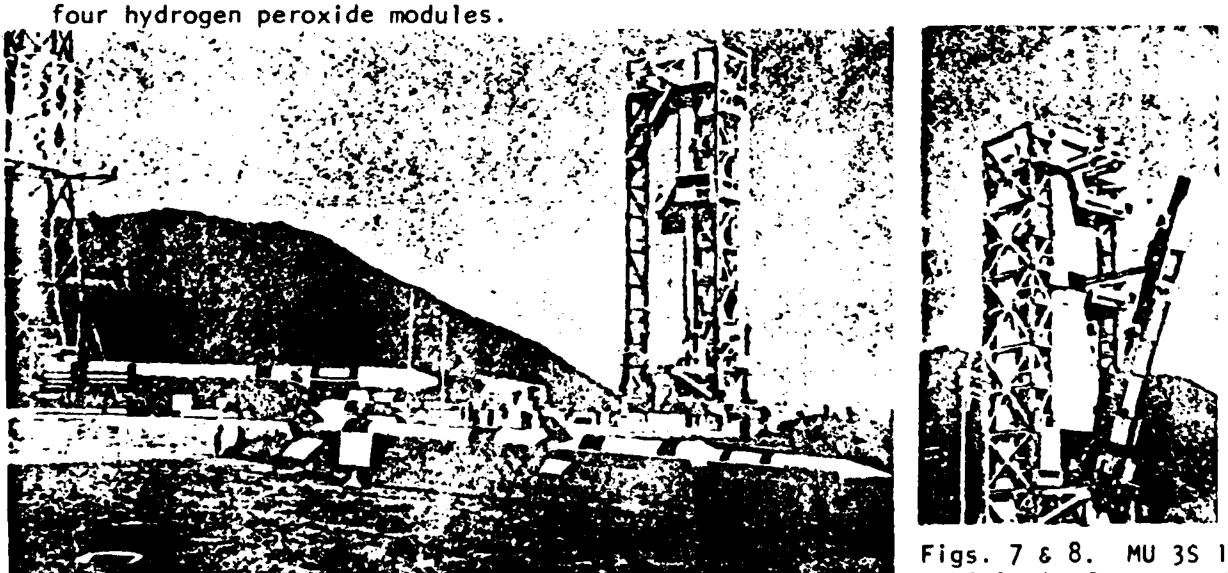


Figs. 5 and 6. MU 3S launch vehicle on transporter vehicle

The first stage is composed of a solid-fuel motor of polybutadiene and weighing 27.1 t with a maraging steel envelope and a reinforced fiber nozzle. The motor delivers an average thrust of $1120 \cdot 10^3$ Newtons (sea level) over 56 sec.

The first stage has eight boosters in four pairs. Each booster develops an average thrust of 133×10^3 Newtons for 5.5 sec. Roll control is installed at the extremity of the four fins.

The second stage, of maraging steel, has a 7.22-t block and delivers an average thrust of 357×10^3 Newtons in a vacuum for 55 sec. Control of the second stage is effected by a gyro station and thrust control by all-or-none valves and four hydrogen peroxide modules. /59



Figs. 7 & 8. MU 3S launch vehicle in foreground and in the background the launch tower (Kagoshima)

Fig. 9. Structural detail of the MU 3S (rear skirt)

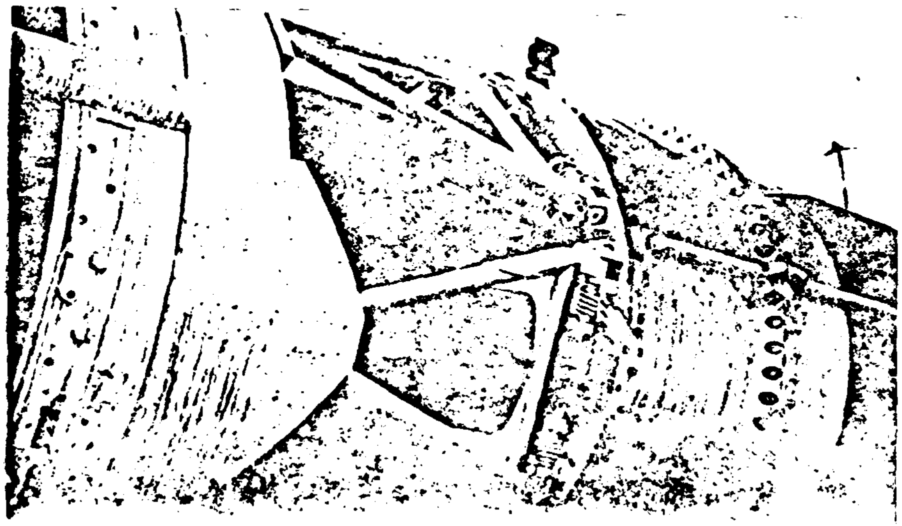


Fig. 10. Structural detail of MU 3S (interstage structure)

The third stage of titanium alloy has a 1.08-t polybutadiene block with a nozzle of wound fibers. The average thrust is 67 x 10^3 N for 45 sec. /60

Engineering Characteristics of the MU 3S Mod I

The total length of the MU 3 Mod I is 28.2 m, with a diameter of 1.65 m. The launch weight is 61 t, and it can put a 700-kg payload into low orbit. The major modifications with respect to the MU 3S consists in the addition of two lengthened boosters, a lengthened second stage, a spherical third stage and a nose fairing 1.65 m in diameter. Each booster will have a controllable nozzle and will develop a thrust of 298 x 10^3 N for 30 sec with a polybutadiene motor.

The second stage (solid propellant, 9 t), will deliver a thrust of 519 x 10^3 N for 52 sec.

The third stage with its spherical 3.3-t block will deliver a thrust of 118 x 10^3 N for 82 sec.

Scientific missions

With the MU 3S Mod I launch vehicle, the ISAS envisages, among other things, launching the PLANET-A probe to observe Halley's comet in March 1986. The mission consists in photographing the nucleus of the comet with an ultraviolet spectrometer and to measure the plasma propagations in space of the inferior planets. This mission would be complementary to that prepared by the United States.

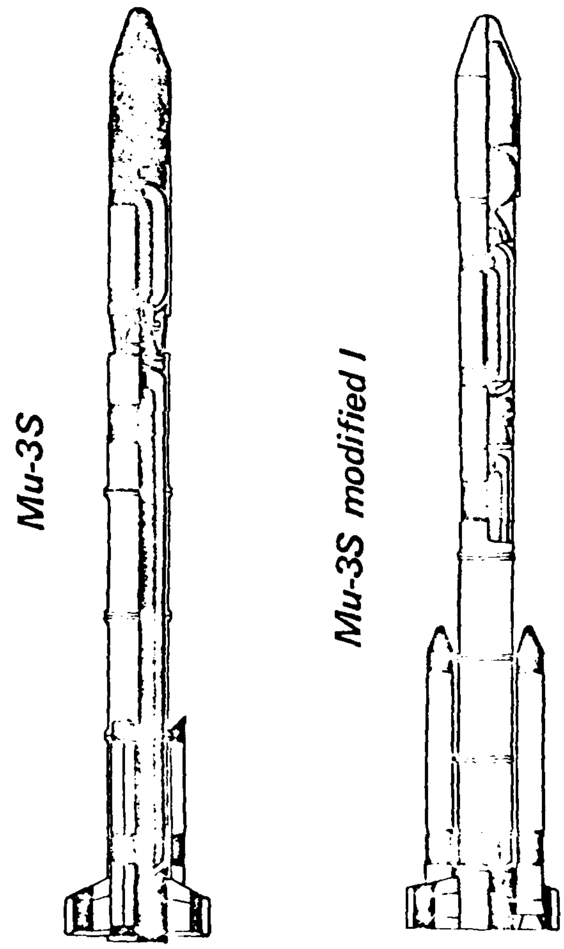


Fig. 11. General configurations of the
MU 3S and MU 3S Mod i launch vehicles

In Fig. 12 below are given the principal scientific missions for the next seven years in which the MU launch vehicle is involved.

LANCEUR	MISSIONS	80	81	82	83	84	85	86	87
MU 3 S n° 1	MS T 4	▼							
MU 3 S n° 2	ASTRO A		▼						
MU 3 S n° 3	ASTRO B			▼					
MU 3 S n° 4	EXOS C				▼				
MU 3 S Mod I n° 1	MS T 15					▽			
MU 3 S Mod I n° 2	PLANET A						▽		
MU 3 S Mod II n° 3	ASTRO C						▽		
MU 3 S Mod II n° 1	MS T 6							▽	
MU 3 S Mod II n° 2	EXOS D								▽

Fig. 12. Scientific missions

a. Launch vehicle b. firm option c. astrophysical satellite d. exosphere satellite e. Fiscal year from April to March f planned g. under study h. solar system proble i. engineering test satellite

Studies on propulsion by hydrogen/liquid oxygen made by the ISAS

The ISAS has been working with the NASDA to develop an LOX-LH_2 propulsion ag of the H1 since 1975. It is a motor with 10,000 kg of thrust which will be t ed in the mid-eighties, and which has a chamber with tubular walls. This motor ι be described later on.

It is, however, interesting to learn that the ISAS is concurrently develo its own LOX-LH_2 motor, which is intended to be the second stage of the present MU launch vehicle in the future.

This will be a motor with 7000 kg of thrust with a chamber of different design (channel wall thrust chamber). t present, the major components of this motor have already been tested and the motor is in the process of integration. Tests started during the second half of 1980. /61

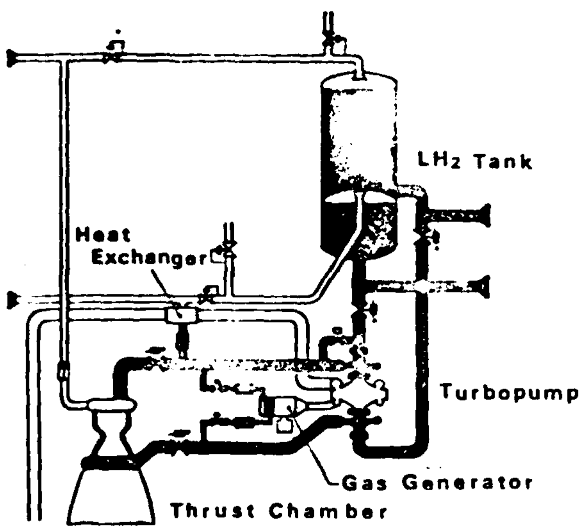


Fig. 13. LOX-LH_2 propulsion system of the ISAS

Fuel is supplied by turbopumps of original design: LOX and LH_2 pumps are arranged at each end of the turbine. Each of the pumps is mounted on each of the

two rotors, which are not interconnected and turn in opposite directions from each other because there is no stator between the two rotors. To start the turbine there is a block of powder which serves as the gas generator.

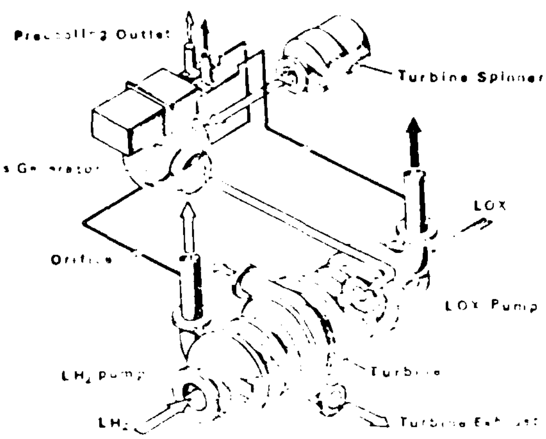


Fig. 14. Fuel supply by turbopump, developed by ISAS

specific impulse (vacuum):	433 s
chamber pressure:	25 kg/cm^2
mixture ratio:	5.2
fuel flow rate:	16.3 l/s
cooling: transpiration (injector)	
cooling: regenerative (chamber)	
number of injector elements:	90 coaxial elements
nozzle expansion ratio:	40 (flight)-7 test).

The N and H Launch Vehicle Family

The domain of space applications is reserved to NASDA. On 23 February 1977 NASDA launched the first Japanese geostationary satellite KIKU 2 (Engineering Test Satellite 2) with its N1 launch vehicle. On 11 February 1981, NASDA successfully launched the technological satellite KIKU 3 (Engineering Test Satellite ETS 4) with its N2 launch vehicle.

Fig. 15 below presents the development of the N and H families of launch vehicles.

The N Launch Vehicles

1. The N1 launch vehicle is a three-stage radio-guided vehicle composed of a first liquid stage with three solid boosters, a second liquid stage and a third stage with a solid motor.

In order to reduce the risks associated with the development of such a vehicle, NASDA elected to use technologies proven in flight and American equipment. Thus, the first stage was built under McDonnel Douglas and Aerojet General license.

The N2 launch vehicle, now under development, offers the following improvements: nine boosters, a first lengthened stage, a high-performance second stage, an inertial guidance system from Delta US, a third improved stage (solid), and a metal nose fairing 2.64 m in diameter.

To satisfy the request of the users, the associated equipment is American.

2. Engineering characteristics of the N2 launch vehicle

The N2 can put a 350-kg payload into a geo-stationary orbit (satellite plus apogee motor). This figure should be compared with the 135 kg of the N1. The first flight of launch vehicle N2 was conducted successfully on 11 February 1982, with the ETS 4 satellite alias KIKU 3 (synchronous transfer orbit) as the payload.

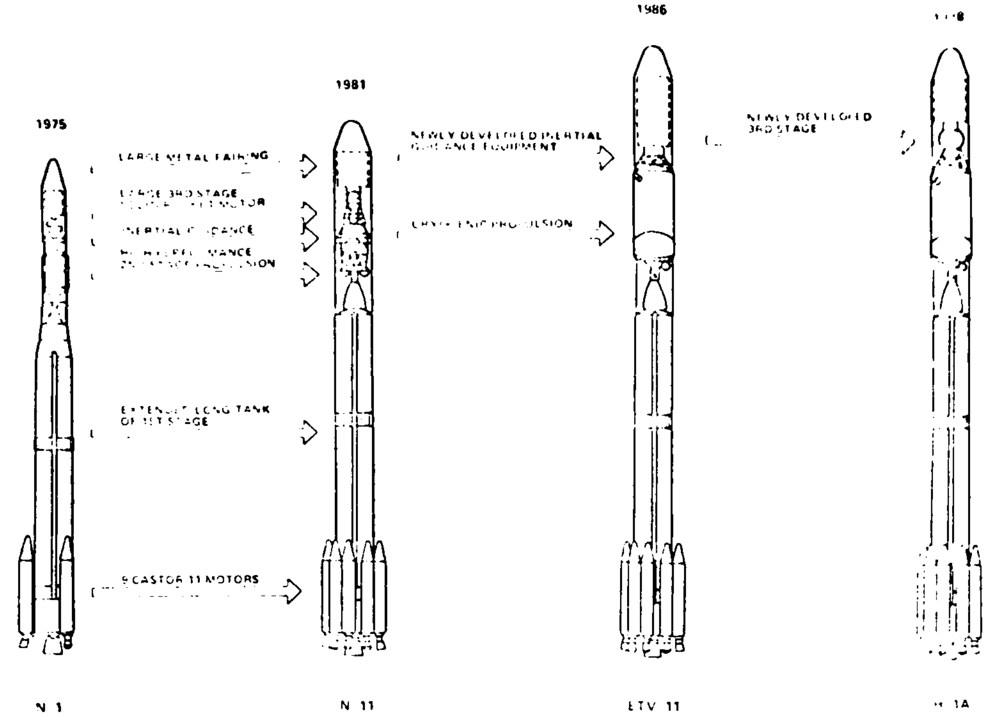


Fig. 15. Development of the N and H launch vehicles

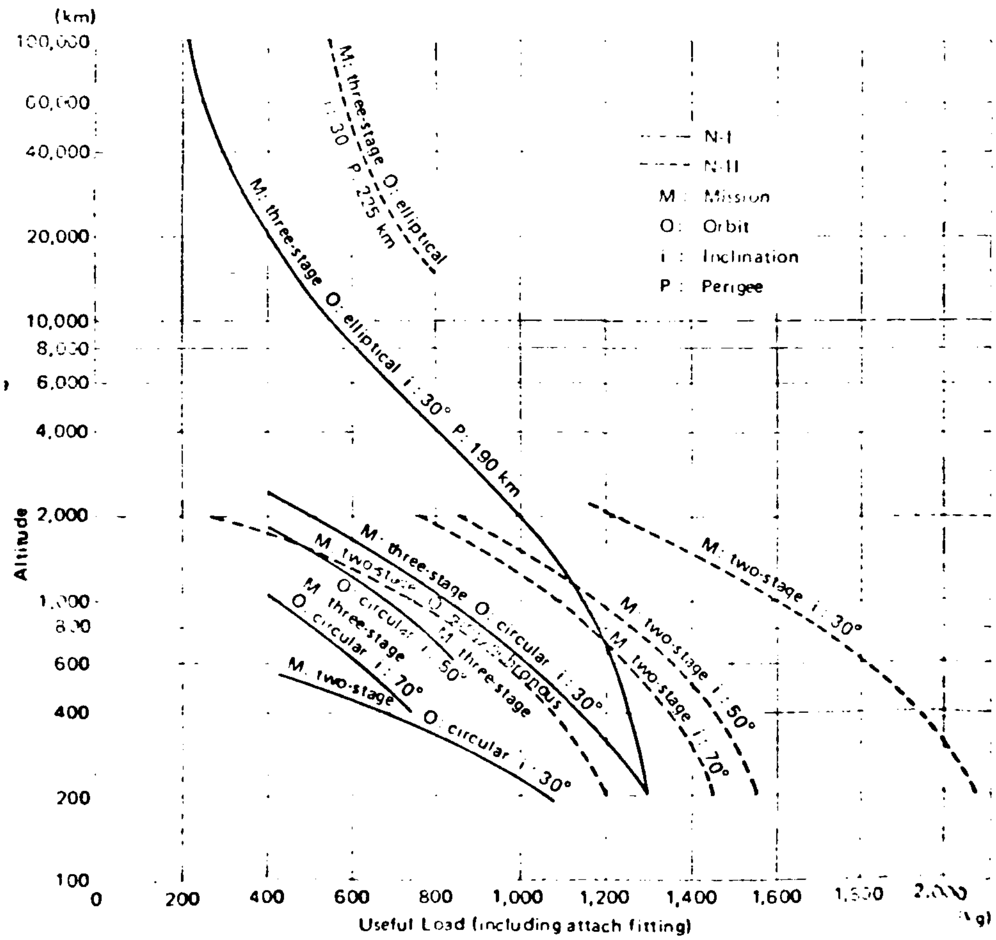
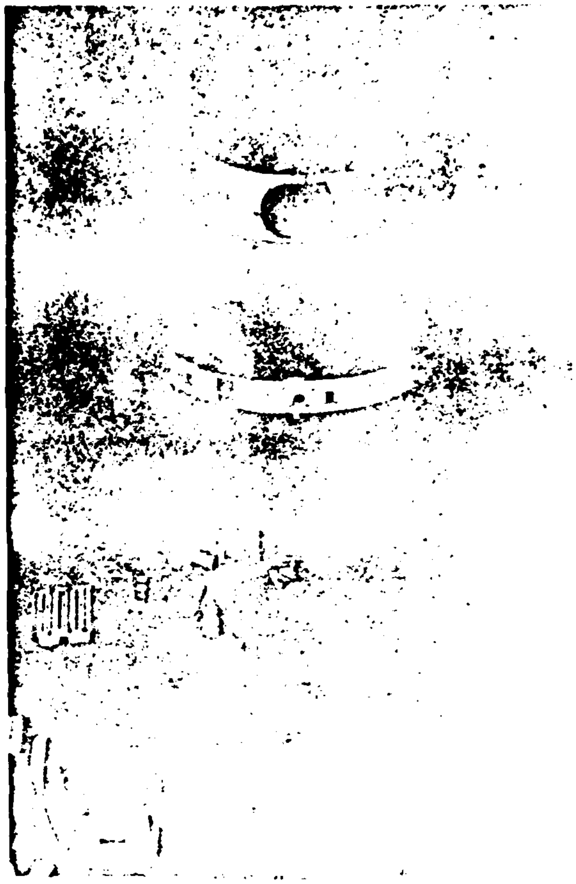


Fig. 16. Performances of the N1 and N2 launch vehicles

Fig. 17. Second stage of launch vehicle N2 (photos taken on the Tanegashima launch site



18. Upper part of second stage

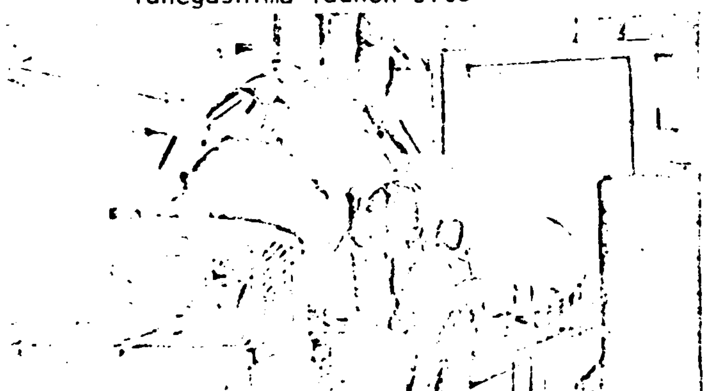


Fig. 18. Upper part of second stage

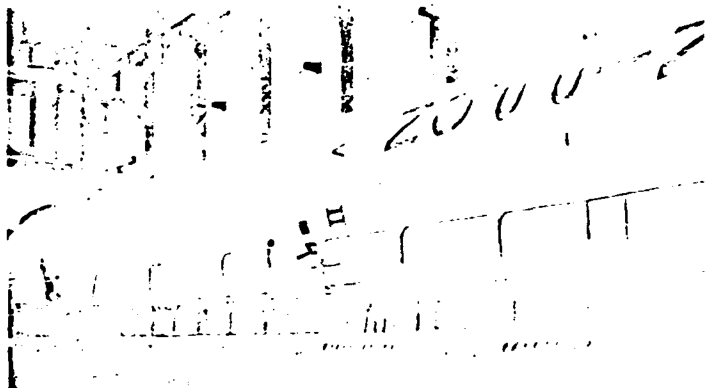


Fig. 19. First stage of N2--flight model (photos taken in a storage shed) (photos by P. Langereux)

The first stage of the N2 launch vehicle has a main motor and 2 vernier engines which provide roll control up to burnout of the main motor followed by three-axis control. The three motors operate with LOX-RJ-1.

The main motor delivers a thrust of 755×10^3 N for 269 sec. The two vernier engines develop an additional thrust of 9.6×10^3 N, and after burnout of the main motor, they develop 1.4×10^3 N. The trajectory and the attitude control of the first stage are provided by an electronic control system and a gimbal upon receiving orders from the second stage.

The tank of the first stage is of aluminum alloy with an isogrid-pattern single-section structure. The body of the lengthened tank holds 23% more fuel than that of the N1 (total of 82 t of fuel).

The nine boosters are powder. Six of them are ignited prior to launch, and the last three after burnout of the first six. All the boosters are released together about 85 sec after liftoff. Each booster delivers a thrust of 232×10^3 N for about 38 sec.

The second stage uses a mixture of nitrogen dioxide-aerozine 50 (50% mixture) and asymmetric dimethylhydrazine (UDMH). The motor cooled by ablation developed 48.3×10^3 N of thrust. It is reignitable and the total time of functioning is 420 sec.

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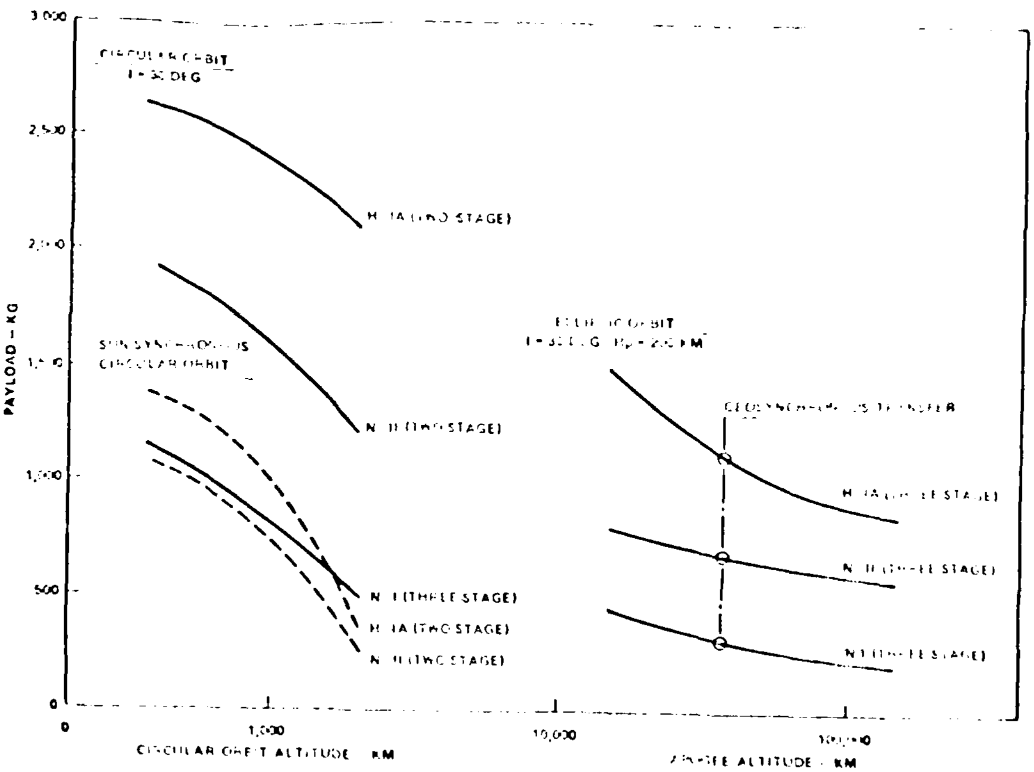

Fig. 20. Comparative performances of the N and H launch vehicles

The tank is of the integral type, stainless steel, and can hold six t of fuel. During the powered stage, the pitch-yaw control of the N2 is provided by a gimbal system on the main motor and the roll control, by an attitude control system. During the non-powered stage and before reignition, the three axes are taken into account by the attitude control system(cold nitrogen gas system).

The Delta inertial guidance system is installed in the guidance part which is in the top of the second stage, because there is no equipment compartment. This system transmits orders to the electronic systems of each stage.

The third stage is composed of a block of polybutadiene of about 1.1 t which develops a thrust of 67×10^3 N for 4.4 sec.

3. Comparison of the N and H Launch Vehicles

The essential changes between the three N1, N2, and H1-A launch vehicles are in the second propulsion stage. Therefore, we have thought it useful to present a table summarizing the latest engineering data on this subject:

		N-I	N-II	H-IA*
DESIGNATION		LE-3	AJ10-118FJ	LE 5
PROPELLANT		NTO/A-50	NTO/A-50	LOX/LH_2
THRUST, VACUUM	(N)	53,000	44,000	98,000
SPECIFIC IMPULES, VACUUM	(s)	290	314	442
COMBUSTION CHAMBER PRESSURE	(kg/cm^2 abs)	11.8	8.8	35.0
BURNING DURATION	(s)	250	420	370
MIXTURE RATIO		1.5	1.9	5.5
OXIDIZER FLOW RATE	(kg/s)	11.25	9.32	19.12
FUEL FLOW RATE	(kg/s)	7.50	4.90	3.43
OXIDIZER TANK PRESSURE	(kg/cm^2, abs)	20.54	15.68	3.2
FUEL TANK PRESSURE	(kg/cm^2, abs)	20.67	15.68	2.5
HELIUM STORAGE PRESSURE	(kg/cm^2, abs)	309.3	306.9	310 (ambient) 210 (cryogenic)
NOZZLE EXIT AREA RATIO		26:1	65:1	140:1
TOTAL PROPELLANT WEIGHT	(kg)	5,376	6,000	8,450
TOTAL DRY SYSTEM WEIGHT	(kg)	656	496	1,135

Fig. 21. Comparison of the second propulsion stages of the N1, N2, and H1-A launch vehicles

The Family of H Launch Vehicles

1. An ETV2 transition launch vehicle

As a first step toward the new H family, NASDA is developing an ETV2 (ngineering Test Vehicle 2) two-stage launch vehicle. The ETV2 is the test vehicle of the H1 as was the ETV1 of the N. ETV2 is the H1-A two-stage launch vehicle.

The first stage and the boosters will be the same as on the N2 to reduce the risks of development, cost, and time.

The second stage will be a cryogenic stage developed in Japan without American assistance and will have inertial guidance.

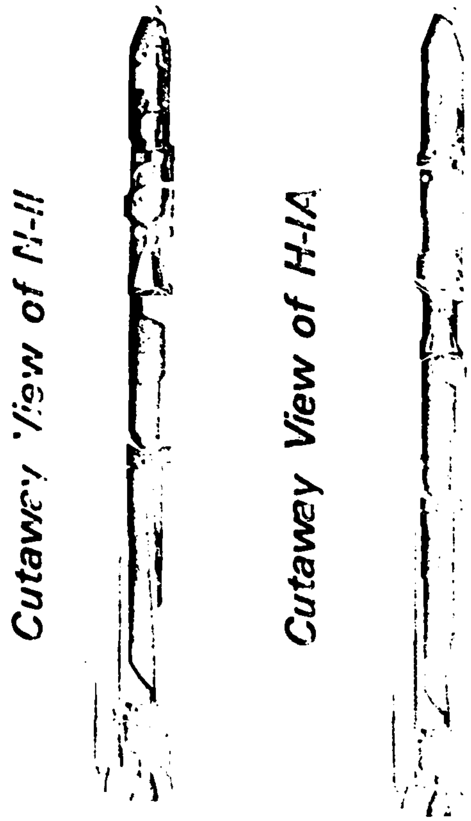

Fig. 22. General configuration of the N2 and H1 launch vehicles

	1er étage	Boosters	2e étage
Ergols	LOX/RJ-1		LOX/LH2
Masse ergols (t)	81 t	3,75 × 9	8,33
Poussée (t)	77 (niv. mer)	23,7 × 9 (niv. mer)	10 (vide)
ISP (s)	252 (niv. mer)	238 (niv. mer)	442 (vide)
Masse totale	140 t		
Masse en orbite 30°	3,2 t/200 km		
Masse orbite Héliosynchrone	1 t/1 000 km		

Fig 23 – Résumé des caractéristiques du lanceur ETV2

Fig. 23. Summary of the characteristics of the ETV2 launch vehicle

a. First stage b. Boosters c. Second stage d. (sea level) e. (vacuum)
f. Fuels g. Propellant weight (tons) h. Thrust (tons) i. Specific impulse (s)
j. Total weight k. Weight in 30° orbit l. Weight sun-synchronous orbit

The H1-A launch vehicle will be an ETV2 for the first two stages, but will have a new third stage. This launch vehicle is supposed to be the "work horse" of the Japanese space industry starting with the second half of the decade of the eighties.

The developmental cost of the H1-A launcher is estimated at present at between 137 and 151 billion yen, or 2560 to 2750 million francs, including two firing tests in flight and one operational test. he manufacturing cost of the H1-A launch vehicle is estimated at 14 billion yen, or 250 million francs.

Fig. 24. The LE-5 motor on the test bed during visit to Tanegashima launch site (photo by P. Langereux)

The H1-B launch vehicle: NASDA is now studying the configuration of the H1-B launch vehicle which is supposed to put a payload of 800 kg to 1000 kg into stationary orbit for 1990.

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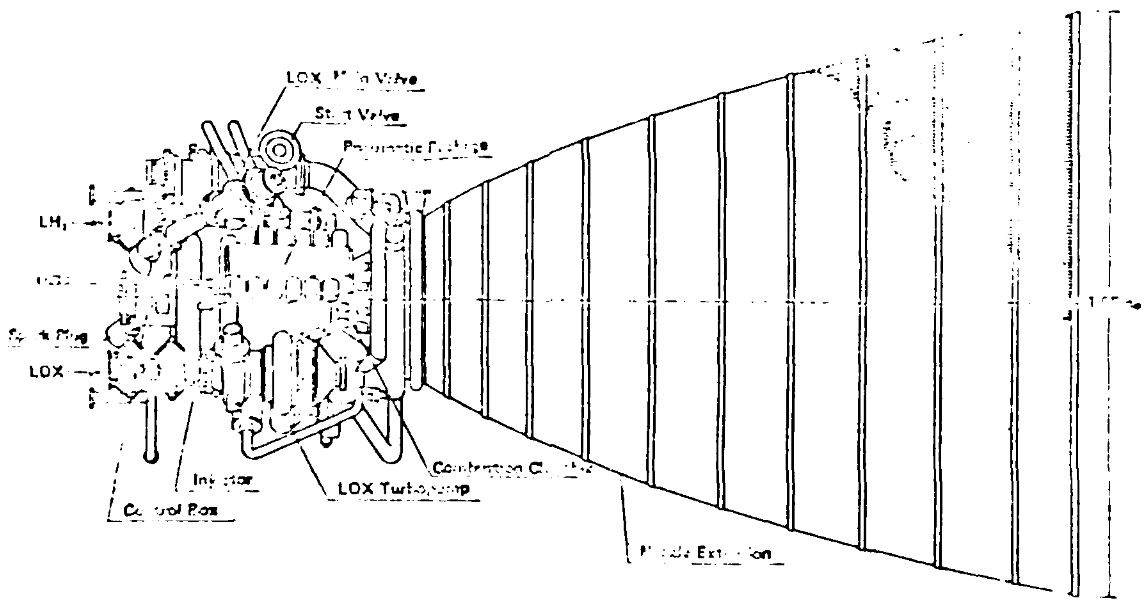


Fig. 25. The LE-5 motor

The H2 launch vehicle. NASDA is also studying the feasibility of an H2 vehicle which is supposed to be a reusable space transport system. This system is said to be able to be available at the end of the 1990s.

2. Engineering characteristics of the H1-A launch vehicle

The H1-A launch vehicle has a total length of about 40 m, a diameter of 2.50 m and a liftoff weight of 140 t.

The H1-A launcher can put into a geostationary orbit a payload of 550 kg compared with the 350 kg for the N2 launcher.

The first stage, the boosters, and the nose fairing are the same as for the N2, except for the command electronics and the adapter. The second and third stages are Japanese developments, without the assistance of the United States, with the cooperation of ISAS of the National Aerospace Laboratory (NAL).

The second stage is a cryogenic stage using LOX-LH_2 as fuels. The LE-5 motor fed by turbopump is reignitable. It develops a thrust of 98×10^3 N, and the Japanese expect to obtain a specific impulse of 442 sec. The total duration of burn is anticipated to be 370 sec. The chamber is composed of stainless steel tubes to permit regenerative cooling.

The isogrid single-section aluminum alloy tank has a common bottom for LOX-LH2 separation.

The exterior surface of the tank as well as the common bottom are thermally insulated. The tank, whose internal pressure is controlled by using the inertial guidance computer, has a capacity of 8.45 t of propellants.

The onboard computer of the inertial guidance system is microprogrammable with words of 16 bits. The frequency of the attitude control is 40 Hz, and that of the guidance, 1.25 Hz. The attitude control system uses hydrazine.

LE-5 MOTOR			
Fuels:	LOX-LH_2	--LH_2 turbopump	
Nozzle expansion rate:	140	Shaft speed:	50,000 rpm
Combustion pressure:	35 kg/cm^2	Pressure discharge:	52.5 kg/cm^2
Mixture ratio:	5.5	--Gas generator	
Turbopump system:	turbines in series	Combustion chamber pressure:	26 kg/cm^2
Fuel flow rate:	LOX: 16.6 l/sec LH_2: 54.6 l/sec	Mixture ratio:	0.9
Combustion duration:	370 sec	Motor weight:	200 kg
Thrust (vacuum):	98,000 kN	Maximal diameter:	1.65 m
Specific impulse:	442 sec	Length:	2.7 m.

Fig. 26. Table of characteristics of the LE-5 motor

/67

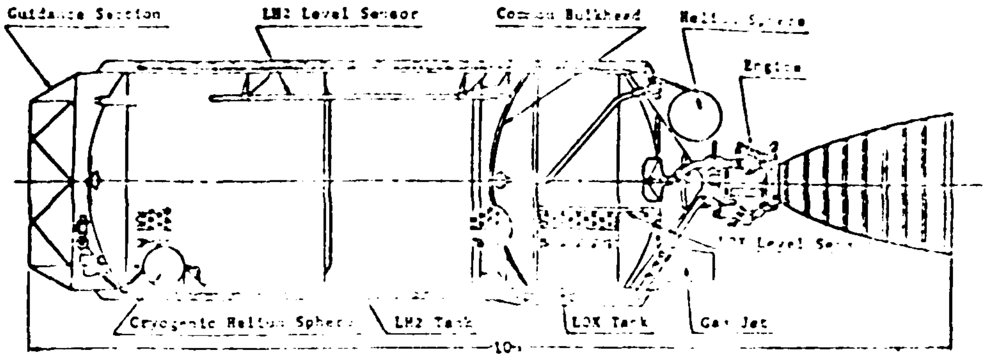


Fig. 27. – Configuration du 2e étage ETV-2 et H1-A.
Configuration of the second stage of the ETV-2 and the H1-A

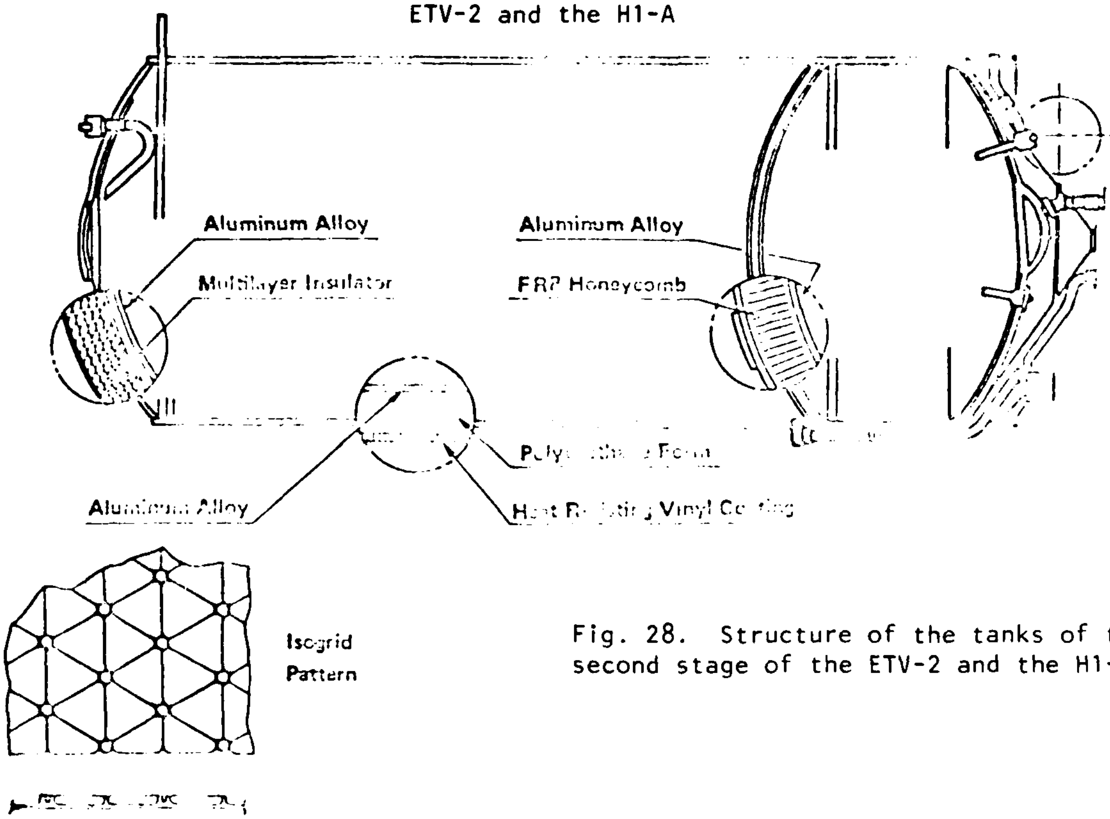


Fig. 28. Structure of the tanks of the second stage of the ETV-2 and the H1-A

The third stage of the H1-A is composed of a block of spherical powder with a retractable nozzle and weighs 1.85 t.

The motor develops a thrust of 78×10^3 N for 66 sec. The type of powder used is HTPB (hydroxyl terminated polybutadiene) and the thermal insulation is provided with EPDM (ethylene propylene dienemonomer). The nozzle is of wound fiber with an expansion rate of about 50, and the specific impulse is above 288 sec.

3. The Missions of the H1-A

With the two-stage H1-A, the Ministry of Commerce and of Industry and the Science and Technology Agency will launch the first Earth Resources Study Satellite

(ERS 1) early in 1987.

The missions of this satellite cover the exploitation of the earth resources, geographic observation, observation of the land and oceans, pollution and environ-

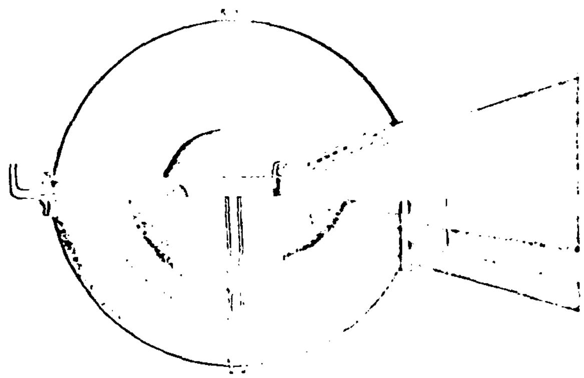


Fig. 29. Motor of the third stage of the H1-A launch vehicle

mental monitoring, earthquake warnings, etc. It will be a three-Axis" satellite with a weight of about 1200 kg, and it will be equipped with a radar with a synthetic opening, an optical radiometer, and an on-board computer.

The vehicle will be put into a circular sun-synchronous orbit at an altitude of between 500 and 700 km.

The list of satellites and missions planned at present by NASDA are shown in Fig. 30.

The Two-Stage Solid-Fuel Ballistic Rockets in Japan

The TT series launch vehicle (probe rocket)

It seemed interesting to mention here the existence of a family of small two-stage solid-fuel launch vehicles developed by NASDA. These vehicles, which were made for civilian purposes, would, it appears, be easily transformable into military vehicles in view of their characteristics.

The essential mission which controlled their design is a mission of calibrating and checking the Japanese tracking and telemetry system for the N1 launch vehicle. The secondary mission is the use of ballistic flight for civilian tests in weightlessness.

The TT 500 A launch vehicle

This is the latest improved version of the TT 500 which is 10.5 m long, 0.50 m in diameter, and has a launch weight of 2.36 t. The launch vehicle can carry a payload of 300 kg for a ballistic flight of more than 400 sec. During this phase of the flight, the acceleration below 10^{-4} g will be used to conduct material processing tests, and the results will serve as a base for future on-board tests on Spacelab.

The first flight of the TT 500A took place on 14 September 1980 (successful launch and recovery).

		a. Véhicule			
		N 1	N 2	ETV 2	H 1 A
b. Taille	Longueur totale (m) 1	32,57	35,36	Approx. 40	Approx. 40
	Diamètre (m ø) 2	2,44	2,44	2,44	2,50
	Poids total (t) (1) 3	90,4	134,7	Approx. 140	Approx. 140
c. 1er étage	Ergols (2) 1	LOX/RJ 1	LOX/RJ 1	LOX/RJ 1	LOX/RJ 1
	Poussée moyenne (2) 2 (niveau mer) 3	77	77	77	77
	Impulsion spécifique (2) 4 (sec) (niveau mer) 5	249	249	249	249
	Total/poids ergols (t) 6	70/66	86(3)/81	86/81	86/81
Booster	Ergols 1	Solid	Solid	Solid	Solid
	Poussée moyenne (t) 2 (niveau mer) 3	23,7 × 3	23,7 × 9	23,7 × 9	23,7 × 9
	Total/poids ergols (t) 4	4,5/3,75 × 3	4,5/3,75 × 9	4,5/3,75 × 9	4,5/3,75 × 9
d. 2e étage	Ergols 1.	N_2O_4/A-50	N_2O_4/A-50	LOX/LH_2	LOX/LH_2
	Poussée moyenne (t) (vide) 2.	5,4	4,4	10	10
	Impulsion spécif. (vide) 3.	285	315	440	442
	Total/poids ergols (t) 4.	5,8 (4)/4,7	6,75/5,80	10,2/8,45	10,2/8,45
e. 3e étage	Ergols 1.	Solid	Solid	-	Solid
	Poussée moyenne (t) (vide) 2.	4,0 (TE-364-14)	6,8 (TE-364-4)	-	7,8
	Poids ergols (t) 3.	0,56	1,05	-	1 [illegible] 5
f. Coiffe	Diamètre (m ø) 1.	1,65	2,44	2,44	2,44
	Diamètre maxi satellite 2.	1,44	Approx. 2	Approx. 2	Approx. 2
g. Système de guidage		Radioguidage	Delta Inertial Guidance System	Inertial	Inertial
h. Charge utile	Orbite géostationnaire (5) 1.	130 kg	350 kg	-	[illegible] kg
	Orbite circulaire (1 000 km/70°) 2.	400 kg	1 100 kg	1 [illegible] kg	

Fig. 30. Recapitulation of the engineering characteristics of the N1, N2 and ETV-2 launch vehicles

a. Vehicle b. Dimensions 1. Total length (m) 2. Diameter (m) 3. Total weight (1) c. First stage 1. Propellants 2. Average thrust 3. (sea level) 4. Specific impulse 5. (sec) (sea level) 6. Total/fuel weight (t) d. Second stage 1. Propellants 2. Average thrust (t) (vacuum) 3. Propellant weight f. Nose fairing 1. Diameter (m) 2. Max. satellite diameter g. Guidance system h. Useful load 1. Geostationary orbit (5) 2. Circular orbit (1000 km/70°) i. Solid j. Radio guidance k. Inertial

1. Except the weight of the satellite and attachments
2. Main motor only
3. Including the interstage
4. Including the adapter
5. Including apogee motor

a LANCEUR	MISSION SATELLITE (*)	80	81	82	83	84	85	86	87	88
N II – GTV	GTV	▼								
N II n° 1	ETS IV	▼								
N II n° 2	GMS 2		▼							
N I n° 7	ETS III			▼						
N II n° 3	CS 2 a			▼						
N II n° 4	CS 2 b				▼					
N II n° 5	BS 2 a				▼					
N II n° 6	GMS 3					▽				
N II n° 7	MOS 1					▼				
N II n° 8	BS 2 b						▼			
N II n° 9	AMES						▽			
ETC II GTV	GTV						▼			
ETV II 1	GS 1						▼			
ETV II 2 b	ECS II c. ou EMEOS							▽		
H 1 A (2 étages) n° 1	ERS 1							▼		
H 1 A (2 étages) n° 2	EMEOS c ou ETS-V								▽	
H 1 A (3 étages) n° 1	GMS 4								▽	
H 1 A (3 étages) n° 2	EBS									▽
H 1 A (3 étages) n° 3	ACTS									▽

d ▼ Lancement ferme ▽ Option f ▽ En cours d'investigation

GTV	modèle pour essais au sol	BS	satellite TV
ETS	satellite d'essai « engineering »	MOS	satellite observation maritime
GMS	satellite météo géostationnaire	AMES	satellite aéronautique & maritime
CS	satellite télécommunication	GS	satellite géodésique
ERS	satellite d'étude des ressources terrestre	EBS	satellite expérimental TV
ECS	satellite expérimental télécomm.	ACTS	satellite de technologies avancées télécomm.
EMEOS	satellite d'observation de l'environnement électromagnétique	(*)	année fiscale de avril à mars

Fig. 31. List of missions planned at present by the NASDA

a. Launch vehicle b. Stages c. or d. Firm launch f. Under study

GTV	Ground Test Vehicle
ETS	Engineering Test Satellite
GMS	Geostationary Meteorological Satellite
CS	Communications Satellite
ERS	Earth Resources Satellite
ECS	Experimental Communication Satellite
EMEOS	Electromagnetic Environment Observation Satellite
BS	TV Satellite
MOS	Maritime Observation Satellite
AMES	Aeronautical and Maritime Satellite
GS	Geodesic Satellite
EBS	Experimental TV Satellite
ACTS	Advanced Communication Technologies Satellite
(*)	Fiscal year from April to March

Other flights are planned to experiment with the production of amorphous semiconductors and the study of crystal growth, etc.

The flight profile of the TT 500A is illustrated in Fig. 32.

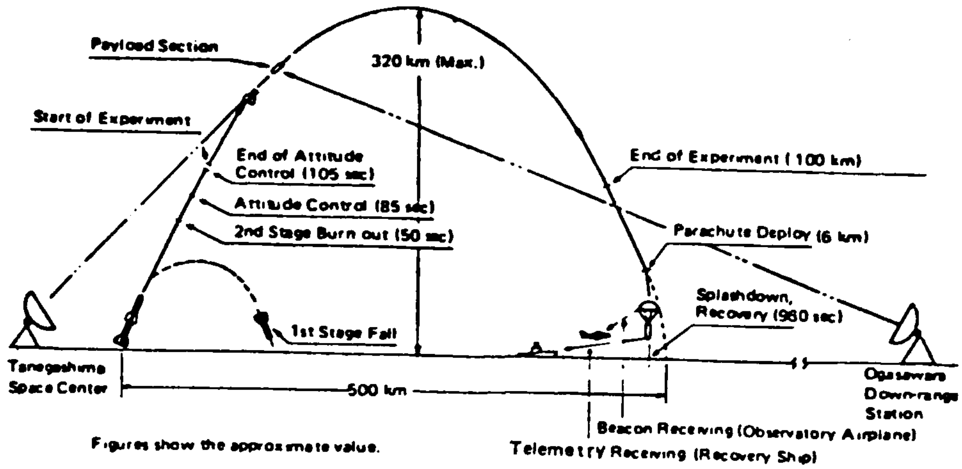
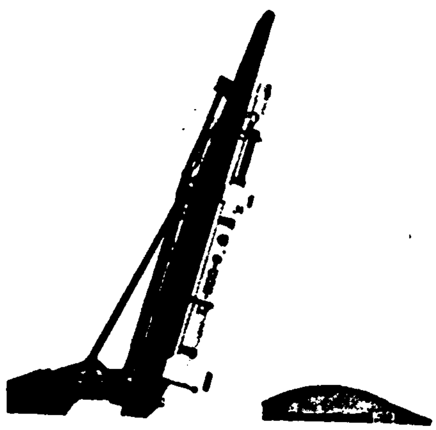


Fig. 32. – Trajectoire classique du TT 500 A.

Fig. 32. Trajectory of the TT 500A



NASDA has confirmed the following experiments for us for the next two launch series:

--January - February 1981: processing of a metallic compound (Ni-Ti C whisker);

--August - September 1981: processing of amorphous semiconductors (Si-As-Te).

Experiments Aboard SPACELAB

Concurrently with its development of MU, N, and H launch vehicles, Japan is heavily engaged in the use of the US space shuttle.

Indeed, Japan now has two missions planned in each of the two lines of her space activity.

First Spacelab experiment of the ISAS

ISAS, in collaboration with the NASA Marshall Center, is engaged in a space experiment with a particle accelerator (SEPAC). The purpose of this experiment /70
is to test the neutralization of the space vehicle and to the study of physics of the plasma jets. It will be conducted during the first flight of Spacelab (Fig. 33).

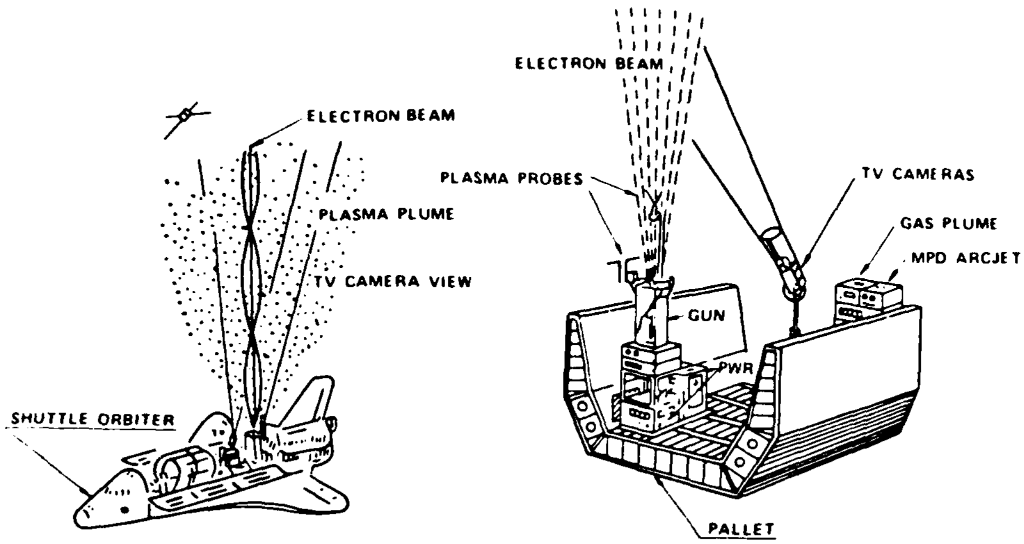


Fig. 33. SEPAC experiment of the University of Tokyo aboard SPACELAB

SPACELAB Experiments of NASDA

NASDA, in collaboration with other Japanese organizations, is working on programs for using the space shuttle in the materials processing area.

The first materials processing tests (FMPT) and a biological experiment will be conducted aboard Spacelab in 1985. For this mission, Japanese mission specialists will be selected to conduct operations in flight. The first tests are currently planned with the Japanese TT 500A launch vehicle mentioned earlier.

Launches Conducted by the American DELTA 2914

From 1977 to 1978, three geostationary satellites were launched by the American Delta 2914. The weight of the satellites as well as the pressing user demand had not permitted the completion of the development of the Japanese N2 launch vehicle.

These three satellites are: the Geostationary Meteorological Satellite (GMS), the medium-capacity experimental communication satellite (CS) SAKURA, and the medium-capacity experimental TV satellite (BSE) YOURI.

The next satellites of this series will be launched by the Japanese N2.

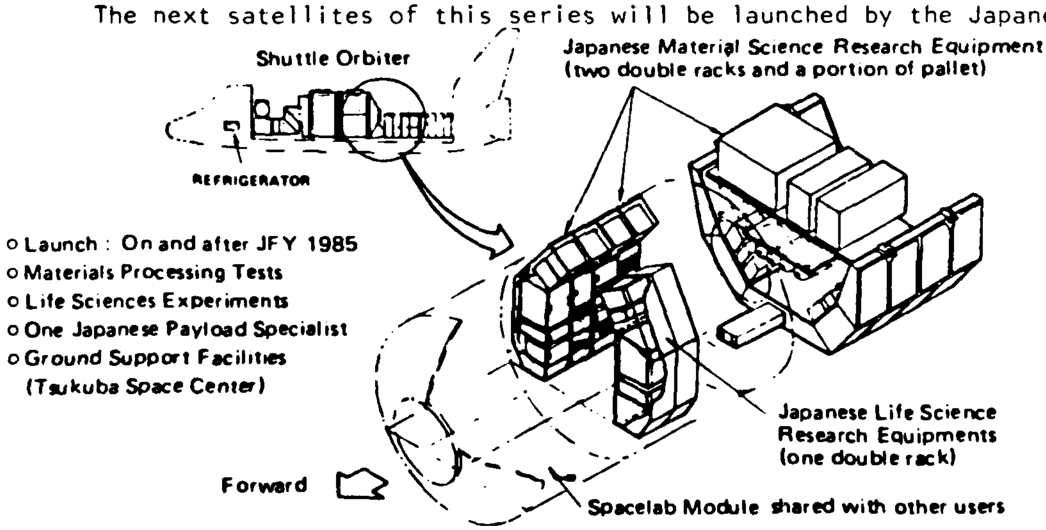


Fig. 34. Material processing experiment in space aboard the US space shuttle

The Tanegashima Space Center

This is the largest launch site in Japan, and it is managed by the NASDA. /71
It is located on Tanegashima island , south of Kyushu. It now has two launch pads, and a third will soon be built. It is larger than the Kourou Center, with an area of 3,670,000 m^2.

The Takesaki launch pad is used to launch the TT 500 As.

The Osaki launch pad is used to launch the N1 and the N2.

On the same island, you will find the Masuda Tracking and Control Station, the Nogi and Uchugaoka Radar Station, the Nakayoama Telemetry Station, two optical tracking stations, as well as a static firing test bed near Osaki (static firing bed for solid and liquid propellants).

On the island, at the Osaki site, there is an assembly shed, a mobile service tower, a firing block, a control center, a storage area for propellants, and a weather center.

It is from this launch pad that the first and second ETV 1s and the N1s (UME, KIKU 2, UME 2, AYAME and AYAME 2) have been launched.

After the last launch, the launch tower and the other installations were modified for the N2 launches.

The Kagoshima Space Center (KSC)

The Kagoshima Space Center is managed by the ISAS and is slightly smaller than the Kourou Center (CSG). This Center is located about 100 km north of the Tanegashima Center, more precisely at Uchinoura, on the Pacific Ocean.

The construction of the Center dates back to 1962, and it has been used for several years for the launching of probe rockets. It was in 1966 that it underwent modifications to permit the launching of the MU launch vehicles. It covers an area of 710,000 m^2.

The installations, which are in a mountaneous area, are distributed over eight levels, and include:

a control center, telemetry stations, a radar station, optical tracking stations, and integration center.

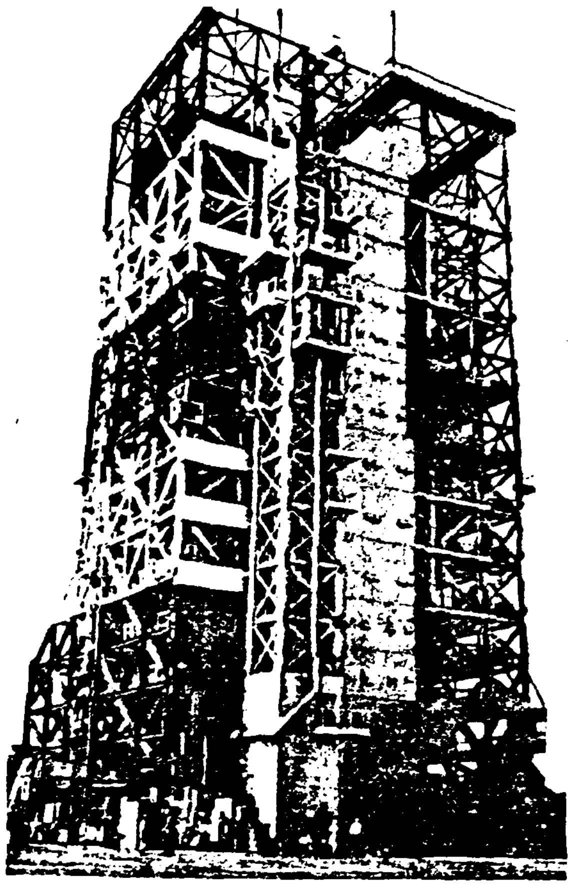


Fig. 36. Mobile assembly and integration tower on the launch pad. The umbilical cord which remains during the launch is seen in the foreground.

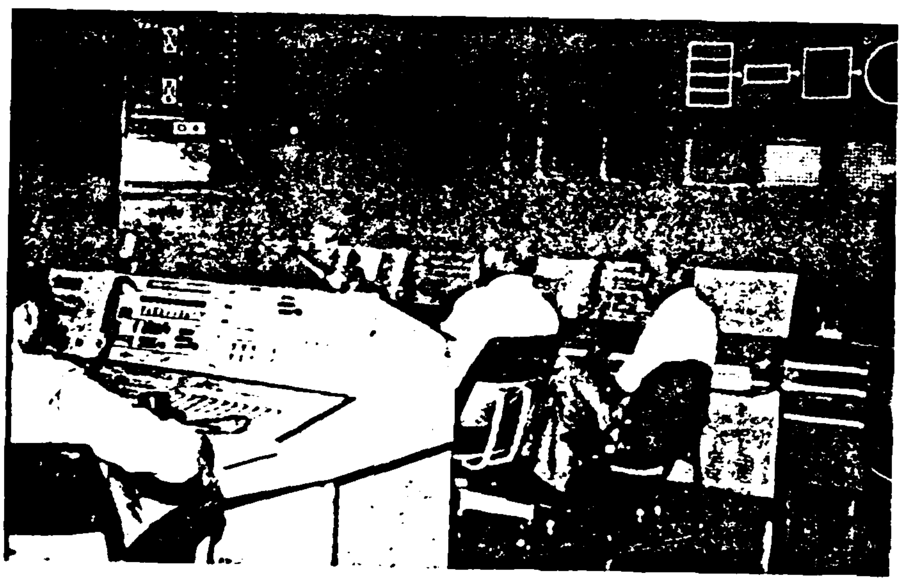


Fig. 37. Launch operations control room

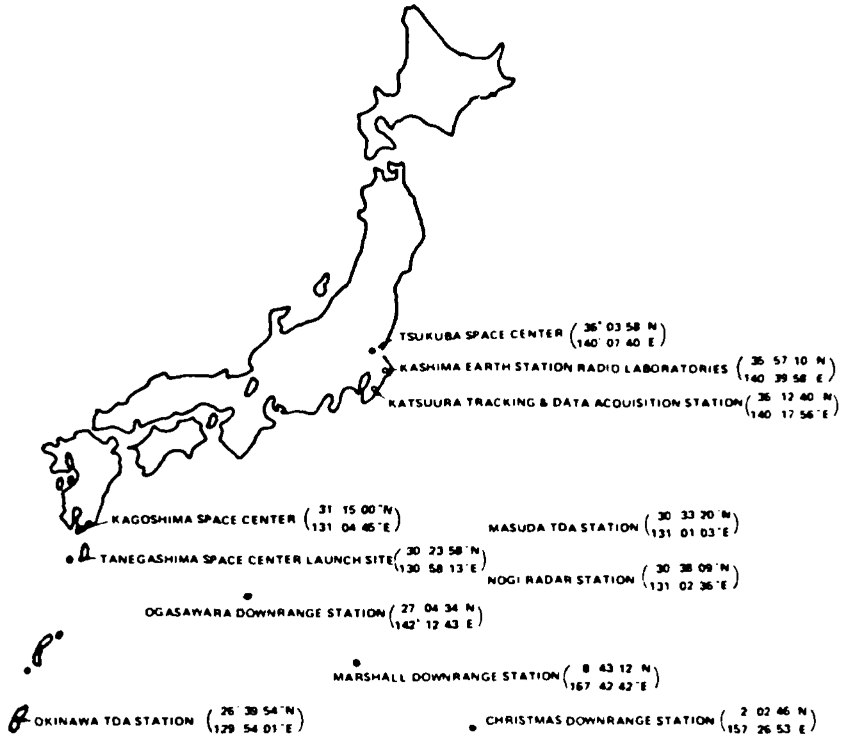


Fig. 38. Geographic locations of the principal Japanese space centers

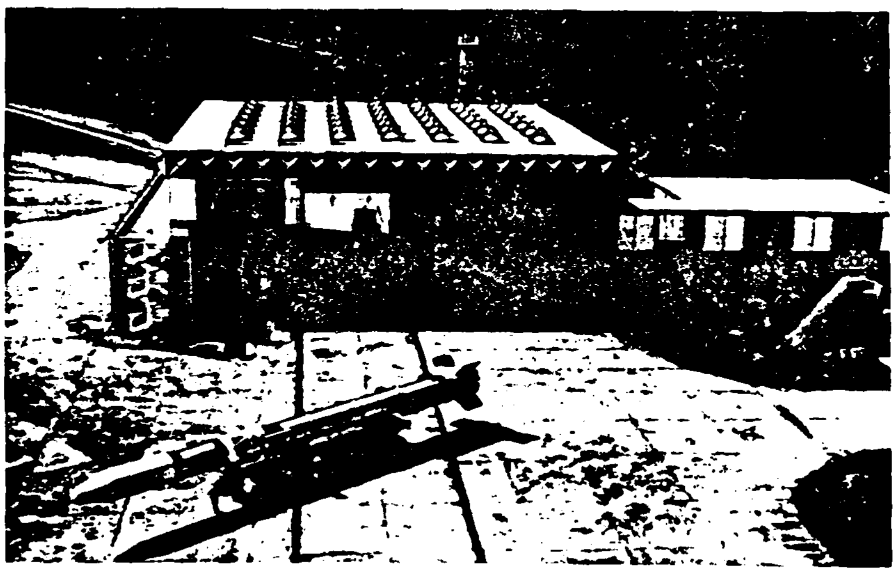


Fig. 39. Storage shed

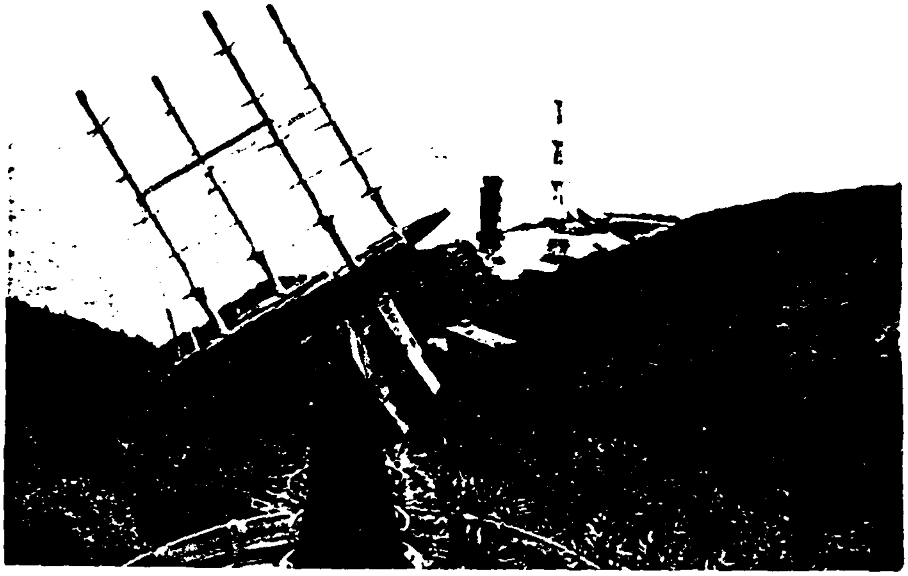


Fig. 40. Tanegashima launch pad

Tracking and Telemetry Installations

NASDA with the Tusbuku Control Center directs the tracking and control operations for itself and for ISAS. The general organization is shown in Fig. 41, with the dotted lines representing the ISAS installations.

By referring to Fig. 38, one can see that the Christmas Island station permits providing launch safety, monitoring of separations as well as the putting /74 into transfer orbit for a geostationary orbit. This is the latest Japanese station; for the remaining coverage, Japan resorts to NASA installations.

The Japanese Space Budget in 1979
(in millions of francs)

--Coordination and administration:	10.86
--National Aerospace Laboratory:	18.62
--NASDA:	1,636.82
--Science and Technology Agency:	1,660.30
--Environmental Agency:	0.40
--Ministry of Education (ISAS):	205.02
--Ministry of Agriculture:	0.96
--Ministry of Commerce and Industry:	1.78
--Ministry of Transport	56.06
--Ministry of Posts & Telecommunications:	58.92
--Ministry of Construction:	0.04
TOTAL:	1,989.48

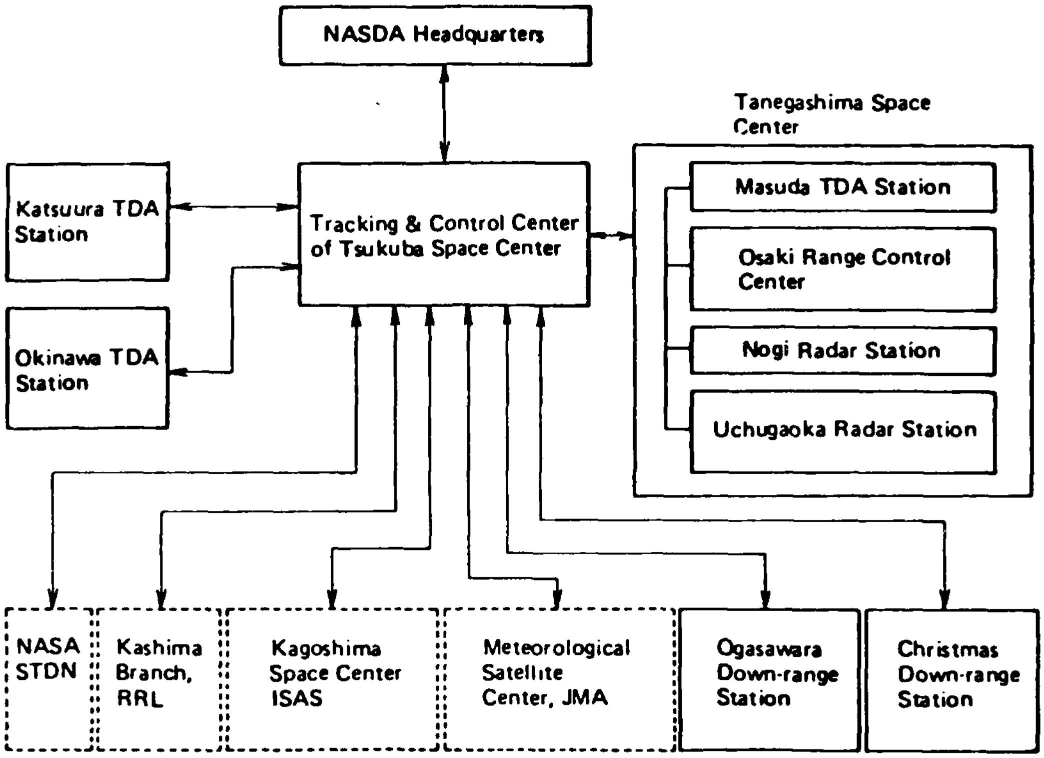
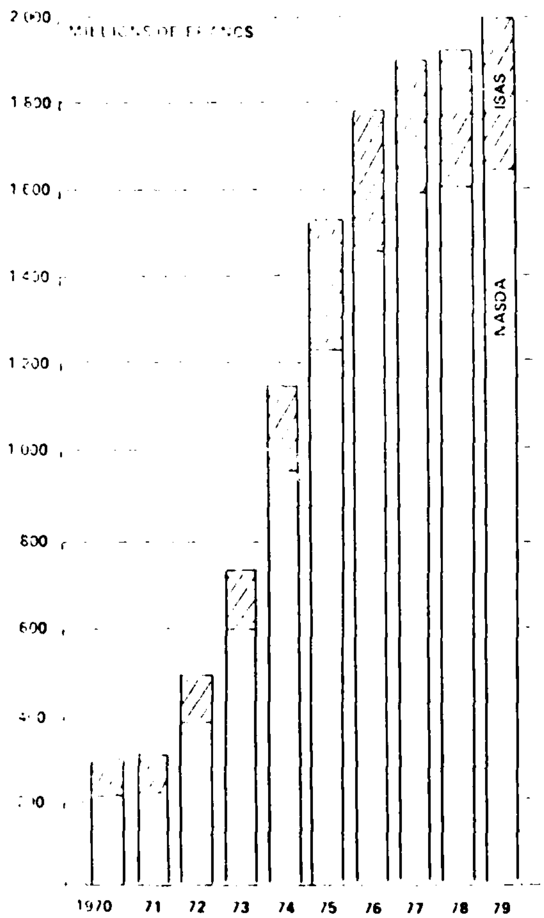


Fig. 41. General organization of control and telemetry installations



Bar Graph: Growth of the Japanese Space Budget

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